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GIACOBINI-ZINNER COMET: POLARIMETRIC AND PHYSICAL OBSERVATIONS

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16. Abstract

The results of observations of the Giacobini-Zinner comet on 25 and 31 October 1959 are presented. The magnitude of the comet was measured photoelectrically in two spectral regions. It was found that the radius is on the order of one kilometer. The photoelectric measurements of Comets 1959b and 1957c were used to measure the abundances of the CN and C_2 radicals and of solid particles in the heads.

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NOTE

POLARIMETRIC OBSERVATIONS OF THE GIACOBINI-ZINNER COMET (1959 b)

by Marie-Therese Martel *[/498]

(Lyon and Haute-Provence Observatories)

AUTHOR'S SUMMARY IN ENGLISH: Results of observations taken on October 25 and 31, 1959 are presented.

The observations were made at the Haute-Provence Observatory in accordance with the method already described (Ref.1).

The best polarimetric picture of the comet is that taken during the first evening of observation, on October 25, on an Eastman photographic plate 103aF without a filter. Two exposures of 20 minutes each were obtained, from 1858hrs to 1943hrs Zulu for analyzer angles parallel to NS and NESW directions. This picture enabled me to determine the polarization of the nucleus and of 15 nearby areas located within 1.5'. The results indicated in Fig. 1 of this note are presented in the same manner as in Ref. 1. On 31 October, under poor atmospheric conditions, I photographed the planet on plate 103aF through a Wratten

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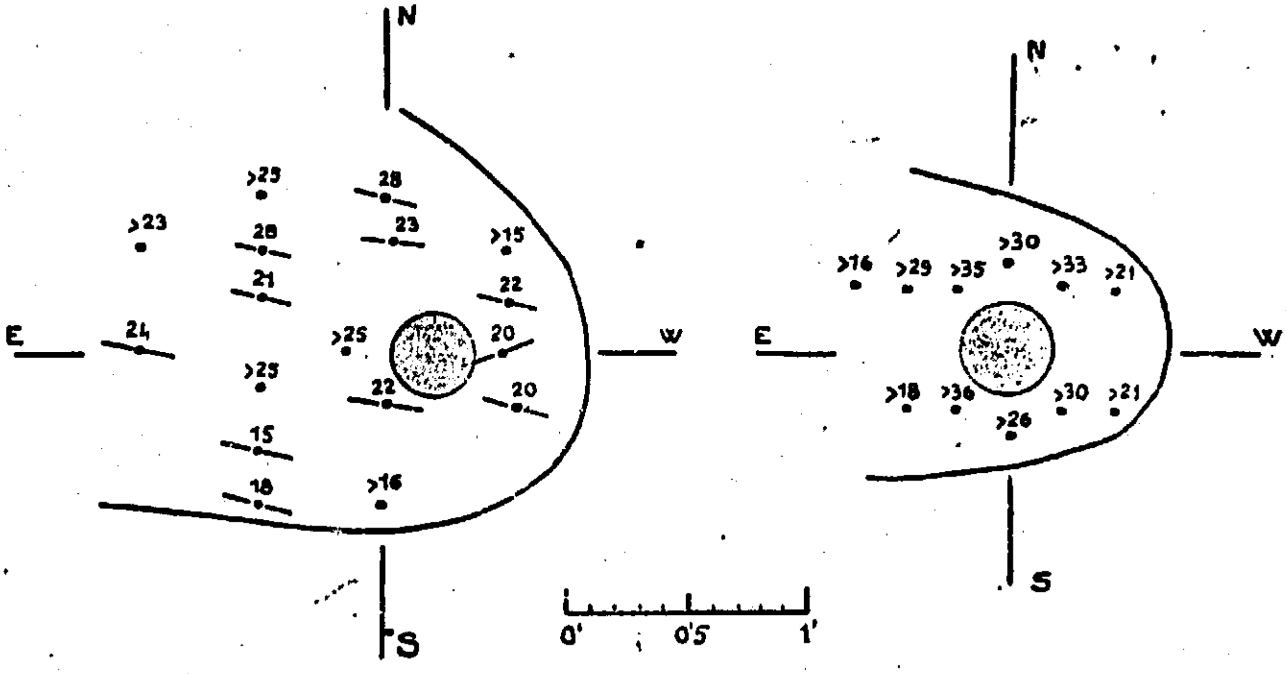

Fig. 1 Fig. 2

2B filter. This filter removes radiations lower than 4000 angstroms.

The polarization of the nucleus, measured on 25 and 31 October, has the following values:

	P	Θ	φ
25 October	26%	83°	86.1°
31 October	25%	73°	87.1°

P being the amount of polarization,

θ the position angle of the plane of polarization with respect to direction N,

φ the phase angle of the comet computed in accordance with Ref. 2.

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PHYSICAL OBSERVATIONS OF THE PERIODIC COMET

GIACOBINNI-ZINNER (1959b)

by P. Mianes

Haute-Provence Observatory

S. Grudzinska* and A. Stawikowski*

Astrophysics Institute of Liege

SUMMARY - The magnitude of the Giacobini- Zimmer (1959b) periodic comet has been measured photoelectrically in two spectral regions, notably within a narrow region centered about the (0-0) band of CN. We have estimated the size of the nucleus: the radius is in the order of one kilometer. We used the photoelectric measurements of Comets 1959b and 1957c to measure the abundances of the CN and C_2 radicals and of solid particles in the heads. /788

AUTHOR'S ABSTRACT IN ENGLISH - The magnitude of Periodic Comet Giacobini-Zinner (1959b) has been measured photoelectrically in two spectral regions, one of them centered around the (0-0) band of CN. The dimension of the nucleus has been estimated: the radius is of the order of one Kilometer. The photoelectric magnitudes of 1959b and 1957c have been used to estimate the abundances of the CN- and C_2 radicals and of solid particles in the heads.

(*) From the Copernic University Observatory in Torun (Poland).

AUTHOR'S ABSTRACT IN RUSSIAN:

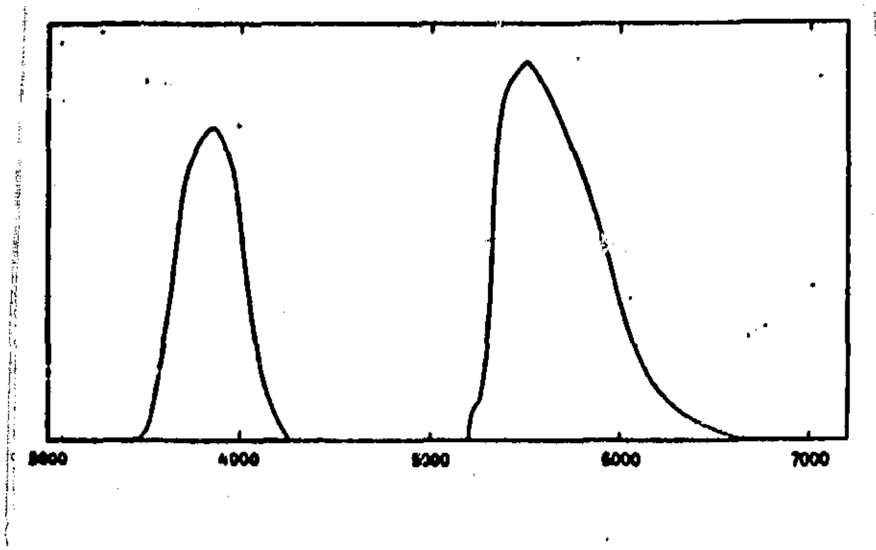
Физические наблюдения периодической кометы Джакобини-Циннера (1959*b*).

Резюме. — Величина периодической кометы Джакобини-Циннера (1959*b*) была фотоэлектрически измерена в двух спектральных областях, одна из которых представляла собой узкий участок с центром, находящимся в полосе (0-0) радикала CN. Были оценены размеры ядра: радиус его оказался порядка одного километра. Для оценки избытков радикалов CN и C_2, а также твердых частиц в головах комет 1959*b* и 1957*c* были использованы фотоэлектрические измерения этих последних.

1. - PHOTOMETRIC OBSERVATIONS

Observations were made by means of the Lallemand cell-equipped photoelectric photometer installed on the 60cm telescope of the Haute-Provence Observatory. Two spectral domains were isolated by means of filters providing magnitudes in the region of the (0-0) band of CN (λ3880) and in the visible domain. The bandpasses of the two combinations: cell, filter, telescope are given in Fig. 1. We have used diaphragms varying from 3 to 13mm in diameter, corresponding to angular apertures of 65" to 283".

As a result of poor weather conditions, the observations were made only during four nights, at rather large zenithal distances (sec $z > 2$); each series of consecutive observations were compared with two stars close to the comet. On the night of 1 November 1959, all of the stars used for comparison were observed photoelectrically in order to make the measurements using a single scale. Table I gives the magnitudes of the stars used for comparison. Columns 2 and 3 indicate m_2 and m_3 measurements with the photometer; column 4 gives the m_3 magnitudes of column 2 reduced to the Johnson-Morgan scale (within a small systematic error) by adding the constant +18.17m; the 5th



/789

Fig. 1. - Bandpasses of the 2 combinations (m_2 on the left, m_3 on the right).

column provides the HD spectrum; the 6th, the HD photometric magnitude (*ptm*); the 7th, the photographic magnitude.

TABLE I

Stars used for comparison

BD	m_2	m_3	V	HD Sp	m_{HD}	m_{pg}
+7°3428	−7.40	−9.38	8.79	A0	8.6	8.6
+6°3502	−8.16	−8.70	9.47	K0	9.0	10.0
+3°3505	−9.66	−10.11	8.06	A2	8.6	8.7
+2°3419	−9.05	−9.50	8.67	A0	8.5	8.5
−10°4738	−5.15	−9.06	9.11	—		
−11°4742	−4.95	−8.84	9.33	—		
−12°5182	−8.14	−9.23	8.94	F8	8.9	9.4

To determine the magnitudes for the entire head, we proceeded as Mianes did previously (Ref. 5); Table II indicates the values of m_2 and m_3 for the different

diaphragms and for the entire head. We can convert to the V magnitudes with the +18.17 correction.

Our measurements are too few for us to deduce the absolute magnitude and the activity index n . Starting with the observations by S.K. Vsessvyatsky (Ref. 10), we find m_0 = 10.9 and n = 10.8; for the 1946 passage V.J. Bouska (Ref. 1) gave m = 10.1 and n = 11.6. These values of n are clearly abnormal since the comet is "essentially" made up of dust and has little "gas" (see Section 3); should we perhaps blamed it on the observations?

TABLE II

m_2 and m_3 Magnitudes Corresponding to the Different Diaphragms and the Entire Head /790

	3 mm		4 mm		6 mm	
	m_2	m_3	m_2	m_3	m_2	m_3
	—	—	—	—	—	—
8 october	−8.04	−8.18	−8.36	−8.43	−8.95	−8.82
12 »	−8.37	−8.54	−8.76	−8.76	−9.20	−9.05
24 »	−8.79	−9.26	−9.13	−9.57	−9.53	−9.90
25 »	−8.95	−9.33	−9.28	−9.59	−9.73	−9.87
	9 mm		**13 mm**		**Tête**	
	m_2	m_3	m_2	m_3	m_2	m_3
	—	—	—	—	—	—
8 october	− 9.37	− 9.07	− 9.78	− 9.28	−10.10	− 9.45
12 »	− 9.63	− 9.25	−10.00	− 9.47	−10.35	− 9.65
24 »	− 9.90	−10.18	−10.41	−10.47	−11.10	−10.85
25 »	−10.16	−10.16	−10.43	−10.35	−11.25	−10.85

2. - SIZE OF THE NUCLEUS OF COMET 1959b.

The question of the dimensions of the comet nuclei is still very much controversial as L. Houziaux (Ref. 4) has shown recently. Miss E. Roemer, from the Flagstaff Naval Observatory Station kindly communicated to Mr. P. Swings her estimates of the magnitudes of the nucleus (Ref. 6). We have used her observations made during 15 nights, from 28 May to 5 November 1959.

Luminosity of a spherical body on which the sun shines is given by:

(1) $$I = \frac{I_0 R^2 A \varphi(\theta)}{r^2 \Delta^2},$$

where R and A are the radius expressed in A.U. and the albedo of the body; r and Δ are the helio and geocentric distances (in astonomical units); φ(O) is the phase function and I_o is a unit luminosity for $r = \Delta = 1$ A.U.; $R = 1$; $A = 1$, $\varphi(\theta) = 1$. We will reduce the visual magnitudes of the nucleus to that of the sun by the /791
relationship:

(2) $$m_{ox} - m_{\odot} = -2{,}5.\log \frac{I_{ox}}{I_{\odot}},$$

or, by adopting $m_{\odot} = -26.72$,

(3) $$m_{ox} = -26{,}72 - 5\,(\log R - \log r - \log \Delta) - 2{,}5 \log A + \log \varphi(\theta).$$

The uncertainty with regard to the albedo of the nucleus is high; we have determined R by means of (3), for two extreme values of the albedo: 0.02 (less than the one used by Cérès: 0.027) and 0.7 (greater than the one applied to Venus: 0.61). For the 15 observations by Miss Roemer,

equation (3) has been applied by introducing the proper values of r, Δ and of the $\varphi(\theta)$ function given by E. Schoenberg (Ref. 7). The values found for R are:

for $A = 0.02$, R included between 2.4 and 7.2km, average value: 4.6km;

for $A = 0.7$, R included between 0.42 and 1.02km, average value: 0.72km.

Therefore, the radius is certainly in the order of one kilometer. Moreover, let us note that for Encke's comet the radius of the nucleus, computed for $A = 0.02$ and 0.7, is 4km or 0.67km, that is to say of the same order as that of 1959b. Yet, the spectra of these two comets are very different: 1959b has a "head of dust" whereas the head of 1957c (Encke) was almost completely gaseous (Ref. 2, 8).

3. - ABUNDANCES OF THE CN AND C_2 RADICALS AND OF DUSTS IN THE PERIODIC COMETS GIACOBINI-ZINNER (1959b) AND ENCKE (1957c).

Comet 1957c (Encke's) was observed photoelectrically by P. Mianes (Ref.5) under the same conditions as 1959b, except for the filter for the visible spectrum for which the bandpass for 1957c covered the 4600-5700 region instead of 5400-6000 for 1959b. Both planets have a short period (Encke: 3.30 years; Giacobini-Zinner: 6.60 years; yet, their spectra are extremely different. Therefore, it appeared interesting to us to estimate, from the

photoelectric measurements, the relative abundances of the CN and C_2 radicals and of the dusts in the two comets.

To estimate the N(CN) and $N(C_2)$ abundances, we proceeded with the method used by K. Wurm to determine the abundance of C_2 in the head of Halley's comet (Ref. 11). We have selected for the oscillation forces f(CN) = 0.026 and $f(C_2)$ = 0.024. The spectrum of Comet 1959b was obtained by J.L. Greenstein and by G.H. Herbig (Ref. 3); the only intense emission is that of the (0-0) band of CN; there is a strong continuum. On the other hand, 1957c only displayed a molecular spectrum, the continuum being practically absent. We have assumed that, for 1959b, the contribution of (0-0)CN in the bandpass of the violet filter was 10 times greater than that of the continuum; for 1957c, we have only retained the contribution of CN. For estimating $N(C_2)$, we have assumed that the intensity of the continuum of 1957c was 10^{-2} times the intensity /792 of Swan's bands; we have also assumed that the continuum is 10 times more intense than Swan's bands for 1959c. Table III gives the average N(CN) and $N(C_2)$ abundances per cm^3 obtained for spheres with an increasing radius R. At nucleocentric distances in the order of 40 or 50000 km, the CN abundances are about equal in the two comets, but C_2 is less abundant in 1959b. These abundances are much lower than the values given by Wurm for Halley's comet but the latter was much brighter than 1959b or 1957c; it

TABLE III

CN and C_2 Abundances in 1959b and 1957c

/793

Comet 1959b R (in 10^4 km)	N(CN)	N(C_2)	Comet 1957c R (in 10^4 km)	N(CN)	N(C_2)
1,16	46,8	2,4			
1,71	13,1	0,7			
2,57	8	0,3			
3,70	3,3	0,1	3,81	3	3,6
5,45	1,1	0,04	5,58	1,9	1,7
			6,24	1,7	1,5
			7,23	1,1	0,9
			8,87	0,5	0,4

is possible that the radius adopted by Wurm was too small. To determine the abundances of dusts, we have, following the work of L. Houziaux (Ref. 4), determined that the continuum was due to diffusion by small solid particles. We computed the required N numbers of particles in order to explain the intensity of the continuum for particles of three different radii: 0.55 μ ; 0.19 μ and 0.36μ; the refraction index used is 1.33. Results are summarized in Table IV: N is the number of grains of dust in the sphere with a radius R, n the number per cm^3, M the mass in grams for the sphere of radius R and ρ the mass per cm^3. For the computation of M and ρ, we have assumed that the particles had as an average density that of solid CO_2 (1.62). The total mass of the dust for 1959b is in the order of 800 tons, that of 1957c is about 20 tons. These masses, relative to "old" comets are less than those

found by V. Vanysek (Ref. 9) for the "young" comets, which is understandable.

We thank Miss Elizabeth Roemer, Mr. J.L. Greenstein, Mr. G.H. Herbig for the precious information that they were willing to communicate to us, as well as Professor P. Swings for the amount of advice that he was willing to give us. Two of us (S. Grudzinska and A. Stawikowski) also express their gratitude to the Royal Academy of Belgium (A. de Potter Foundation) for the subsidy that made it possible for them to participate in this study.

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/794

TABLE IV

ABUNDANCES OF SOLID PARTICLES IN 1959b and 1957c

A. By assuming a radius of 0.055μ

Comet 1959b					Comet 1957c				
R (in 10^4 km)	N	n	M	ρ	R (in 10^4 km)	N	n	M	ρ
1,16	$3{,}5 \times 10^{23}$	$58{,}1 \times 10^{-7}$	$3{,}0 \times 10^{8}$	$0{,}5 \times 10^{-21}$					
1,71	$4{,}4 \times 10^{23}$	$20{,}8 \times 10^{-7}$	$4{,}9 \times 10^{8}$	$2{,}3 \times 10^{-21}$					
2,57	$5{,}9 \times 10^{23}$	$8{,}3 \times 10^{-7}$	$6{,}6 \times 10^{8}$	$0{,}9 \times 10^{-21}$					
3,79	$7{,}2 \times 10^{23}$	$3{,}1 \times 10^{-7}$	$8{,}1 \times 10^{8}$	$0{,}3 \times 10^{-21}$	3,81	$1{,}5 \times 10^{22}$	$6{,}3 \times 10^{-9}$	$1{,}7 \times 10^{7}$	$7{,}1 \times 10^{-24}$
5,45	$7{,}6 \times 10^{23}$	$1{,}1 \times 10^{-7}$	$8{,}5 \times 10^{8}$	$0{,}1 \times 10^{-21}$	5,58	$1{,}0 \times 10^{22}$	$2{,}8 \times 10^{-9}$	$2{,}2 \times 10^{7}$	$3{,}1 \times 10^{-24}$
					6,24	$2{,}4 \times 10^{22}$	$2{,}3 \times 10^{-9}$	$2{,}7 \times 10^{7}$	$2{,}6 \times 10^{-24}$
					7,23	$2{,}1 \times 10^{22}$	$1{,}5 \times 10^{-9}$	$2{,}4 \times 10^{7}$	$1{,}7 \times 10^{-24}$
					8,87	$2{,}1 \times 10^{22}$	$0{,}7 \times 10^{-9}$	$2{,}4 \times 10^{7}$	$0{,}8 \times 10^{-24}$

B. By assuming a radius of 0.19μ

Comet 1959b					Comet 1957c				
R (in 10^4 km)	N	n	M	ρ	R (in 10^4 km)	N	n	M	ρ
1,16	$0{,}9 \times 10^{22}$	$15{,}1 \times 10^{-8}$	$4{,}2 \times 10^{8}$	$7{,}0 \times 10^{-21}$					
1,71	$1{,}2 \times 10^{22}$	$5{,}0 \times 10^{-8}$	$5{,}4 \times 10^{8}$	$2{,}3 \times 10^{-21}$					
2,57	$1{,}5 \times 10^{22}$	$2{,}2 \times 10^{-8}$	$7{,}2 \times 10^{8}$	$1{,}0 \times 10^{-21}$					
3,79	$1{,}9 \times 10^{22}$	$0{,}8 \times 10^{-8}$	$8{,}7 \times 10^{8}$	$0{,}4 \times 10^{-21}$	3,81	$3{,}9 \times 10^{20}$	$16{,}6 \times 10^{-11}$	$1{,}8 \times 10^{7}$	$7{,}8 \times 10^{-24}$
5,45	$2{,}0 \times 10^{22}$	$0{,}3 \times 10^{-8}$	$9{,}5 \times 10^{8}$	$0{,}1 \times 10^{-21}$	5,58	$5{,}1 \times 10^{20}$	$7{,}4 \times 10^{-11}$	$2{,}4 \times 10^{7}$	$3{,}4 \times 10^{-24}$
					6,24	$6{,}2 \times 10^{20}$	$6{,}1 \times 10^{-11}$	$2{,}0 \times 10^{7}$	$2{,}8 \times 10^{-24}$
					7,23	$5{,}7 \times 10^{20}$	$4{,}0 \times 10^{-11}$	$2{,}6 \times 10^{7}$	$1{,}0 \times 10^{-24}$
					8,87	$5{,}7 \times 10^{20}$	$2{,}0 \times 10^{-11}$	$2{,}7 \times 10^{7}$	$0{,}9 \times 10^{-24}$

TABLE IV (continued)

C. By assuming a radius of 0.36 μ.

Comet 1959b					Comet 1957_3				
R (in 10^4 km)	N	n	M	ρ	R (in 10^4 km)	N	n	M	ρ
1,16	$1,7 \times 10^{21}$	$28,0 \times 10^{-9}$	$5,3 \times 10^{8}$	$8,8 \times 10^{-21}$					
1,71	$2,1 \times 10^{21}$	$9,0 \times 10^{-9}$	$6,6 \times 10^{8}$	$2,8 \times 10^{-21}$					
2,57	$2,8 \times 10^{21}$	$3,0 \times 10^{-9}$	$8,8 \times 10^{8}$	$1,2 \times 10^{-21}$					
3,70	$3,4 \times 10^{21}$	$1,5 \times 10^{-9}$	$10,7 \times 10^{8}$	$0,5 \times 10^{-21}$	3,81	$6,2 \times 10^{19}$	$26,9 \times 10^{-12}$	$2,0 \times 10^{7}$	$8,5 \times 10^{-24}$
5,45	$3,5 \times 10^{21}$	$0,5 \times 10^{-9}$	$10,9 \times 10^{8}$	$0,2 \times 10^{-21}$	5,58	$8,1 \times 10^{19}$	$11,6 \times 10^{-12}$	$2,5 \times 10^{7}$	$3,7 \times 10^{-24}$
					6,24	$9,7 \times 10^{19}$	$9,6 \times 10^{-12}$	$3,1 \times 10^{7}$	$3,0 \times 10^{-24}$
					7,23	$8,9 \times 10^{19}$	$6,3 \times 10^{-12}$	$2,8 \times 10^{7}$	$2,0 \times 10^{-24}$
					8,87	$9,1 \times 10^{19}$	$3,1 \times 10^{-12}$	$2,9 \times 10^{7}$	$1,0 \times 10^{-24}$

/795

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